Desaturation Spells in the Neonate

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Objectives

- Determine underlying mechanisms in infants
- Recognize the potential consequences of intermittent desaturation episodes

Disclosure

- I have no actual or potential conflict of interest in relation to this program.

Desaturation Spells in the Neonate

- Lessons from the preterm infant
  - Etiology
  - Management
  - Resolution
- Approach to the term infant
  - Population at risk
  - Relationship to feeds
  - Disposition

Decreased Respiratory Drive

- APNEA, HYPOVENTILATION
- incr. vagal tone
- BRADYCARDIA
- carotid body
- des. O2 delivery
- DESATURATION

Respiratory Reflexes and Neonatal Apnea

- IMMATURITY
- enhanced inhibitory reflexes
- decreased hypercapnic responses
- central hypoxic depression
- APNEA
Kansas City 2009: Desaturation Spells in the Neonate

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Modulation of Central Chemoreceptor Function and Integration During Development

- Inhibition at the Ventral Medulla
- Decreased Central Chemosensitivity
- Enhanced Sensitivity to Laryngeal Inhibition
- Greater Hypoxic Depression
- Preferential Inhibition of Neural Output to Upper Airway

Physiologic Data From Upper Airway Dilator Muscles During Development

- Alae nasi (AN)
- Genioglossus (GG)
- Sternohyoid (SH)
- Posterior Cricoarytenoid (PCA)

HEART RATE (BPM)
CHEST WALL MOVEMENT
TIDAL VOLUME (cc)

Mixed Apnea

180 - HEART RATE (BPM)
120 -
60 -

15 - CHEST WALL MOVEMENT
15 - TIDAL VOLUME (cc)

Direct and Indirect Measurement of Ventilation

Nasal mask pneumotach
Inductance plethysmograph bands

V1
BC
AB
ECG
HR
SaO2

0 5 10 15 20 25 Seconds
Therapeutic Approaches

Interventions of proven efficacy
- Treat specific etiologies (e.g. Sepsis)
- CPAP
- Xanthine therapy

Nasal CPAP for Neonatal Apnea
- Decrease in upper airway resistance
- Increase in FRC
- Improvement in oxygenation

Caffeine Therapy for Apnea Trial: Outcome at 18-21 Months

<table>
<thead>
<tr>
<th></th>
<th>Caffeine</th>
<th>Placebo</th>
<th>OR</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death or disability</td>
<td>40%</td>
<td>46%</td>
<td>0.77</td>
<td>0.006</td>
</tr>
<tr>
<td>Cerebral palsy</td>
<td>4.4%</td>
<td>7.3%</td>
<td>0.58</td>
<td>0.009</td>
</tr>
<tr>
<td>MDI&lt;85</td>
<td>34%</td>
<td>38%</td>
<td>0.80</td>
<td>0.035</td>
</tr>
<tr>
<td>Severe ROP</td>
<td>5.1%</td>
<td>7.9%</td>
<td>0.63</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Schmidt, NEJM 2007

Infants with ≥ One Extreme Event per 20,000 Monitor Hours

Proposed Morbidities of Intermittent Hypoxia

Acute morbidity [e.g., retinopathy of prematurity]
Respiratory instability [e.g., sleep disordered breathing]
Cardiovascular instability [e.g., hypertension]
Neurodevelopmental disability
**Relationship Between Apnea and Outcome: Issues**

- Multiple confounders need to be considered
- Does a relationship reflect association or causation?
- Quantification of apnea, bradycardia and desaturation is a challenge

**Neonatal Apnea and SIDS**

<table>
<thead>
<tr>
<th>Age</th>
<th>Relative Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-term</td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td></td>
</tr>
<tr>
<td>3 mo</td>
<td></td>
</tr>
<tr>
<td>6 mo</td>
<td></td>
</tr>
</tbody>
</table>

24 wks GA

40 wks GA

\{ SIDS (m±SD) \}

**Proposed Respiratory SIDS Pathway**

**Reasons for Neonatal Discharge Monitoring (2009) at Rainbow**

- GER/Aspiration 24%
- Oxygen 16%
- Failed Car Seat Challenge 5%
- Tracheostomy/Ventilator 16%

*Comprises ~3% of all NICU discharges

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**Postnatal Ages of a Term Cohort Admitted for Cardiorespiratory Monitoring**

<table>
<thead>
<tr>
<th>Postnatal Age (Months)</th>
<th>Number of Infants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>
Patients with ALTEs Requiring Hospitalization vs No Hospitalization

<table>
<thead>
<tr>
<th>Characteristic [%]</th>
<th>Yes</th>
<th>No</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple ALTEs</td>
<td>87.5</td>
<td>13.5</td>
<td>0.001</td>
</tr>
<tr>
<td>Prematurity</td>
<td>37.5</td>
<td>3.9</td>
<td>0.009</td>
</tr>
</tbody>
</table>

Relative Risk of Having an Extreme Event on Hospital Monitoring

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Relative Risk</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex</td>
<td>1.2</td>
<td>0.71-2.2</td>
<td>0.443</td>
</tr>
<tr>
<td>Winter months</td>
<td>1.6</td>
<td>0.89-2.7</td>
<td>0.121</td>
</tr>
<tr>
<td>PCA&lt;43 weeks (males and females)</td>
<td>5.2</td>
<td>2.6-10.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Males with PCA &lt;43 weeks</td>
<td>8.7</td>
<td>2.7-27.8</td>
<td>0.0001</td>
</tr>
<tr>
<td>Females with PCA &lt;43 weeks</td>
<td>2.8</td>
<td>1.09-7.3</td>
<td>0.033</td>
</tr>
<tr>
<td>Prematurity</td>
<td>6.3</td>
<td>3.6-11.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Symptoms of URTI</td>
<td>11.2</td>
<td>6.7-18.9</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Al-Kindy, J Pediatr 2009

Characteristic Respiratory Response to Oral Feeding in a Preterm Infant

Al-Kindy, J Pediatr 2009

Gastroesophageal Reflux and Apnea

Herbst, J Pediatr 1979
Kansas City 2009: Desaturation Spells in the Neonate

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Methods: Effect of GER on Apnea Duration

<table>
<thead>
<tr>
<th>Before GER</th>
<th>During GER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnea before GER</td>
<td>Apnea during GER</td>
</tr>
<tr>
<td>30 sec Before</td>
<td>Acid Gastroesophageal Reflux During</td>
</tr>
</tbody>
</table>

DiFiore, Pediatrics 2005

Effect of GER on Apnea Duration

(n=27 infants)

Apnea Duration (sec)

Before GER

During GER

DiFiore, Pediatrics 2005

Effect of Feeding on O₂ Saturation

Before

During

After

BPD VLBW TERM

Singer et al Pediatrics 1992

Approach to the Term Infants with a Dusky Episode

Relationship to feeds

consider nursing, lactation consultation

Neurologic signs

consider EEG, CNS imaging

Baseline Hypoxemia

consider cardiorespiratory evaluation

Suspected apnea

Consider pneumogram

Multichannel Intraluminal Impedance Monitoring
Disposition for Term Infants Admitted for Diagnostic Cardiorespiratory Monitoring

- No Treatment
- Home Monitor
- Thickened Feedings
- Pharmacotherapy for GER
- Antiepileptics

RB&C Data 2008

Thank You